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Various Models of Traditional Solar Distillation System for Water Desalination – A Review

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Abstract: In developing countries, lack of safe and unreliable drinking water constitutes a major problem. The radiation from the sun evaporates water inside the solar still at a temperature higher. In this attempt has been made to review, in brief, work on solar distillation, and its present status in the world today. Many conventional and non-conventional techniques have been developed for water purification. Among these, solar distillation proves to be both economical and eco-friendly technique. The review also includes various models of distillation system for water purification. The classification of distillation units has been done on the basis of literature survey till today. Depending upon the climatic condition the system performance varies. Active and passive solar systems are discussed. Hybrid systems are optimum one for the place having less sunlight intensity.

Keywords: Active and passive solar system, conventional technique, developing nation, eco-friendly, sunlight.

INTRODUCTION

More than two-third of the earth's surface is covered with water. More than 97% of the earth's water is salty; rest around 2.6% is fresh water. In the fresh waterless than 1% is within human reach. Nature itself provides most of the required fresh water, through hydrological cycle. Solar distillation resembles formation of rain. The essential features are summarized as the production of vapors above the surface of the liquids, the transport of vapors by winds, the cooling of air– vapor mixture, condensation and precipitation. This complicated process is performed in a small scale using traditional solar system. As the population is increasing day by day and the available water is being used in enormous amount, it is important to find a conventional way to get fresh water. The process of getting fresh water from saline/ brackish water can be done easily and economically by desalination. According to World Health Organization (WHO), the permissible limit of salinity in water is 500 ppm and for special cases up to 1000 ppm while most of the water available on earth has the salinity up to 10,000 ppm whereas seawater normally has salinity in the range of 35,000–45,000 ppm in the form of total dissolved salts. Excess brackishness causes alteration in physical properties of the water. This is accomplished by several desalination methods like reverse osmosis, electro dialysis, vapor compression, multistage flash distillation, multiple-effect distillation and solar distillation, which are used for purification of water. Among these, the solar stills can be used for desalination process in less demand condition. It is considered to be economical because, no big investment is needed for the process setup. Since other desalination plants are uneconomical for low-capacity fresh water demand, under these situations, solar stills are viewed as means to attain self-reliance and ensure regular supply of water. Solar distillation is a traditional technology. The first "conventional" solar still plant was built in 1872 by the Swedish engineer Charles Wilson in the mining community of Las Salinas in what is now northern Chile (Region II).Many design variations exist, and a wide variety of construction materials are used[1]. The amount of distilled water that can be produced varies quite dramatically with the geographical position, the sun's position, prevailing meteorological conditions, solar still design, and operational techniques[2].

CLASSIFICATION OF SOLAR DISTILLATION SYSTEM

On the basis of various modifications and mode of operations introduced in conventional solar stills, these solar distillation systems are classified as passive and active solar stills. In the case of active solar stills, an extra-thermal energy by external mode is fed into the basin of passive solar still for faster evaporation. The external mode may be collector/concentrator panel[3-6], waste thermal energy from any chemical/industrial plant[7]. If no such external mode is used then that type of solar still is known as passive solar still[8-11].A roof type solar still is simple in construction. This still is composed of bended heat penetrating plates at the center having channel for liquid flow below the crease of bending[12].

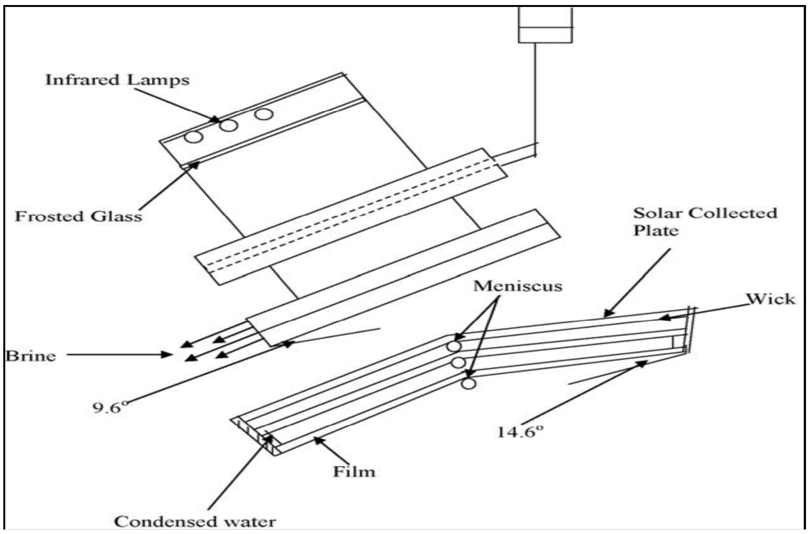

Figure 1: Roof type solar still[13]

A portion of salt water is evaporated from the surface of fibrous sheet by receiving heat from the upper plate and condensed above the opposite surface. The condensed fresh water is collected in rectangular tubes at the both sides of the still as shown in **Figure 1.**

Water Film Type Solar Still: The water film type of a solar still is simple in construction, a cheap and easy method for providing fresh water. It consists of a basin, glass cover having thickness 5 mm and cooling film thickness 1.3 mm. Different types of construction also made in this type solar still. Continuous supply of water film is fed over the glass cover in order to reduce the glass temperature. Several improvements have been proposed such as the use of forced convection, a dye, and external condensers[14]. In order to increase the rate of sun intensity, the basin is colored black. Practical difficulty faced in this system is the glass should be cooled continuously. The efficiency of the above system is improved by preheating the feed water.

Multi-Effect Diffusion Type Solar Still: Multiple effect diffusion type solar still has great potential because of high productivity and simplicity. Multiple effect diffusion type solar still consists of a flat plate reflector, casters for manual azimuth tracking and vertical multiple effect diffusion type still, which consists of a glass cover and number of vertical and parallel partitions with narrow gaps between partitions. As per study ofAayush[15] the height of the still is 1 m. Length of the flat plate reflector is 1 m. width of the still and flat late reflector is 1 m. A Diffusion gap between partitions is 5 mm. Air gap between the glass cover and first partitions is 10 mm. Absorptive of the front surface of the first partition for sun ray is 0.9. Emissivity of glass cover is 0.9, and total number of partitions is 10. A schematic diagram is shown in **Figure 2**.

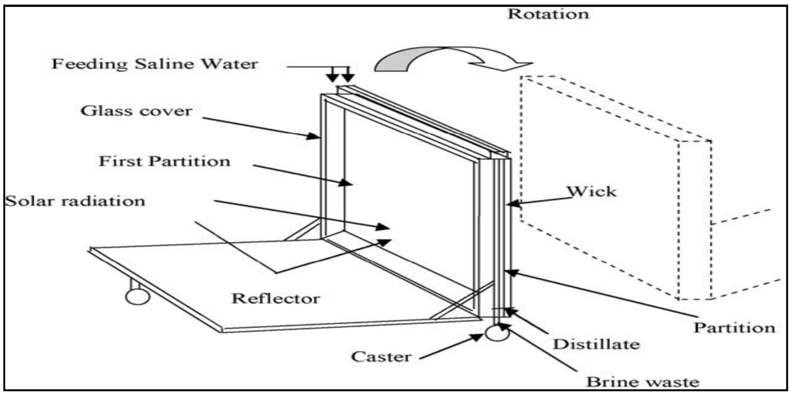

Figure 2: multiple effect diffusion type solar still[15]

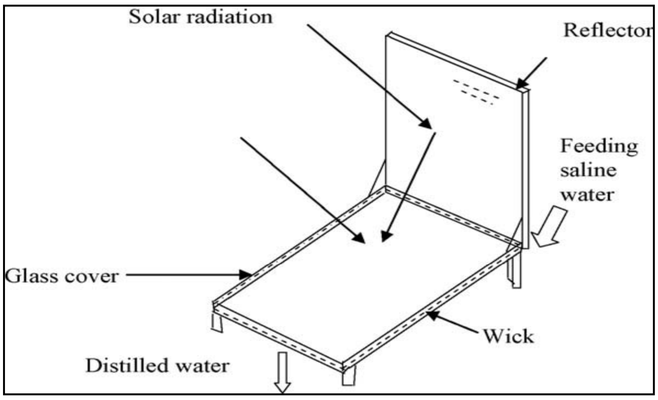

Figure 3: Tilted wick still with vertical flat plate external reflector[19]

The water vapor diffuses through a humid air layer between the partitions and condenses on the front surface of the next partition. Latent heat from condensation is recovered to cause further evaporation from the saline soaked wick of second partition[16-19].Evaporation and condensation process is repeated on all partitions in diffusion type still. Tanaka *et al.*[20] have carried out the study which is presented on a vertical multiple effect diffusion type solar still. By reducing the gap between partitions, the productivity can be increased. Tanaka *et al.*[21-23]also indicated that vertical type of still has greater advantages over the inclined multi-effect diffusion type solar still but there is required an additional arrangement to absorb the solar radiation effectively, and proposed a vertical multi-effect diffusion type solar still coupled with basin type still.

Tilted Wick Solar Still: Tilted wick still with flat plate reflector is very simple in construction. It consists of a glass cover, evaporating wick and a vertical flat plate external reflector of highly reflective materials such as mirror finished metal plate. Saline water is fed to the wick constantly. The direct and diffuse solar radiation and also reflected solar radiation from external reflector are transmitted through the glass cover and absorbed on to the wick. Malik *et al*[1] have also indicated one of their still, which can be useful to increase the productivity for the tilted wick solar still.Sodha*etal*[24] have given their concepts to increase the productivity of the still.

Double Effect Active Solar Still: Tiwari and Sharma[25] studied the double effect solar distillation under active mode of operation using heat exchanger. The study shows that, there is an increase of about 30% in the active solar still due to water flow through the upper basin and there is a marginal increase in efficiency with increase in the length of the heat exchanger. By convection and radiation processes, the rate of evaporation of water from a water surface will be higher than the rate of release of heat from the glass cover to ambient. In this type of distillation, the heat loss from glass to ambient is increased. And this heat loss from glass is used for further distillation. Then overall efficiency of the distillation unit under active modes of operation can be increased significantly. Kumar Sanjeev and Tiwari[26] presented the performance of daily yield for an active double effect distillation system with water flow shown in **Figure 4**. With the increase in water masses, the operating water temperature in the lower basin is lowered resulting in reduced yield and efficiency. The daily yield increases with an increase of collector area, because the thermal energy in the basin increases as the collector area increases.

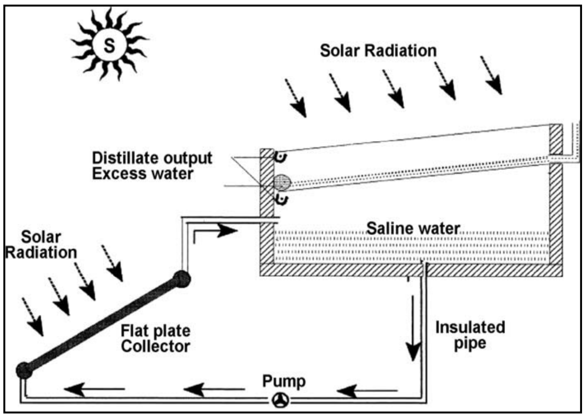

Figure 4: Schematic of double effect solar still coupled with flat plate collector[26]

The Capillary Film Solar Distiller: The capillary film solar distiller presents the advantage of heat recovery shown in **Figure 5**. Instead of a thick spongy fabric, a very thin fabric comprising a single, finely woven layer is held in contact with the overhanging plate through the interfacial tension which is much greater than the force due to gravity. A capillary film is formed at the plate fabric interface. The system developed to provide different constant low flow rates of saline solution is based on the use of hypodermic syringe needles which are readily available in pharmacies at low cost and in a range of diameters.

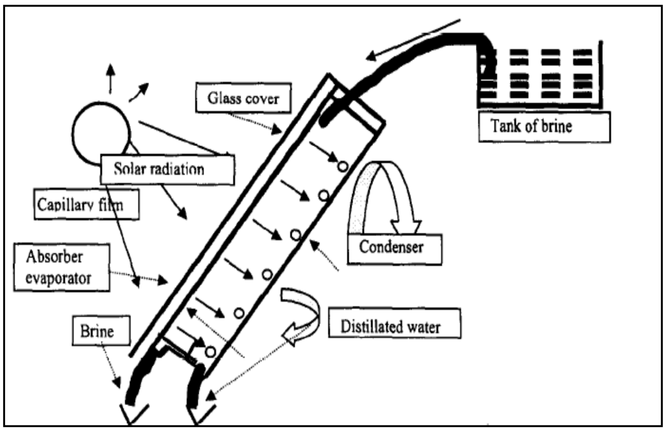

Figure 5: Capillary film distiller

CONCLUSION

Converting brackish water to pure distilled water by low cost method is used all over world. This clean water can be used for laboratory purpose. Different types of solar distillation system explained above were practiced in various parts of the world. Climatic conditions play a vital role in the distillation system. Hybrid systems were used if there is a considerable change in sunlight intensity. Solar stills remove microbes causing water-borne diseases. Solar stills offer the only realistic and cost-effective means to provide safe distill water for many industrial and demotic use. Drawback of the system is if the process is made for large scale, scale formation need to be removed. Apart from this, solar distillation is a reliable technique for water desalinization.

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